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Västerbottens län
15 • 1997

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I NORRBOTTENS LÄN
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Censusing Spring Population of Willow Grouse and Rock Ptarmigan

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Foreword

The Swedish mountains form the eastern part of the Scandinavian mountain range and covers an area of 7-8 million hectares, depending on how it is defined. The mountain area shows great environmental variation from north to south, and is subject to increasing exploitation and thus to an increasing number of factors affecting the environment.

Sweden has nationally as well as internationally engaged to conserve the biological diversity in the different ecosystems in the country, including the mountains. For successful management of the mountain flora and fauna, acording to preset environmental goals and international responsibilities, a well developed monitoring system is an absolute necessity.

In the Swedish mountains the willow grouse and the rock ptarmigan are preyed upon by a number of predators, but their importance as prey species varies greatly. During years with a higt small rodent abundance the predation decreases significantly. The birds are the main food source for the gyrfalcon and are also an important food source for the golden eagle and for larger predators like lynx, wolverine, arctid- and red fox. They are also popular game species for human hunters.

The purpose of this report is to suggest methods for inventories of willow grouse and rock ptarmigan in spring. The next step, whitch will be presented in a coming report, is to suggest a system for large scale monitoring of the willow grouse and rock ptarmigan populations throughout the entire mountain range. The work is conducted by Maria Hörnell and Tomas Willebrand at the Department of Animal Ecology at the Swedixh University of Agricultural Sciences (SLU).

Mats-Rune Bergström
County Administration of Västerbotten

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1. INTRODUCTION

Managers need scientifically sound information to design and evaluate actions supposed to influence environmental factors regulating populations, e.g. population status of key species is necessary for correct management decisions. At all professional levels, there is a need for accurate and reliable monitoring programs for management and conservation of wildlife populations (Trauger 1981). In recent years, the need for accepted and standardised techniques for conducting counts and analysing data has increased.

Almost all decisions on how a population might best be managed require either information on density, on trend in density, or on both (Caughley and Sinclair 1994). Some studies, such as sustained-yield harvesting, require estimates of absolute density, while in other studies relative density is sufficient, e.g. habitat use and population reaction to manipulation (Caughley 1977). The estimate selected depends on study purpose, species, season, and habitat (Bull 1981). The acceptability of an estimate depends upon how it will be used; bias, variance and cost must be evaluated in relation to the information needed. The resources may be better used on other actions than density estimates if available resources are not sufficient to obtain the desired quality.

Estimating the size of bird populations can be difficult. There are many factors affecting their detection, e.g. habitat in the study area, time of day and year, weather conditions, species, sex of the target individuals and even characteristics of the observer. Several methods demand that such influences are standardised by holding variables as constant as possible. The areas of interest are typically large, which makes surveying laborious and expensive (Högmander *et al.* 1996). There are a large number of techniques available to estimate bird numbers. Most techniques will provide an index of relative density, but it is rarely known if this index shows a linear relationship with density. Risk of bias and reduced precision often has to be accepted due to lack of resources or time to evaluate techniques. Therefore, it is important to find techniques that are robust and provide information on the precision of the given

estimate. Distance sampling seems to have many advantages, and provides a robust estimate of true density as well as of its precision (Buckland *et al.* 1993).
Willow grouse (*Lagopus lagopus*) and rock ptarmigan (*Lagopus mutus*) dominate the resident herbivores of the Swedish mountain range. They are an important source for several predators including the gyr falcon (*Falco rusticolus*) as well as being popular game for many hunters. Willow grouse and rock ptarmigan are being considered as suitable monitoring species of the mountain range if robust methods with enough precision can be developed. The aim of this report is to evaluate the resources needed and quality of results obtained from three different approaches to estimate abundance of these two species in spring.

We counted calling males at 30 points which were visited twice. The data collected was used to estimate density by distance sampling using exact distances, distance sampling using only one distance (binomial method), and only determining if the species of interest was present or absent within a given radius of a point. We compared the rate of detection when using taped refrains of territorial males with only passive listening. Males fitted with radio-transmitters were used to evaluate response-rates. We suggest that the most efficient use of resources to obtain an estimate of willow grouse spring populations, is the binomial method if an estimate of true density is required, and the presence/absence index if the aim is to detect any long term trend. It was impossible to compare different techniques for rock ptarmigan, as the sample sizes for that species were too small. We have only evaluated the methods described in this report, and have not compared them with other methods. Distance sampling of willow grouse through line transects with pointing dogs is presently evaluated (Willebrand).

2. CHARACTERISTICS OF SCANDINAVIAN WILLOW GROUSE AND ROCK PTARMIGAN

Spring densities of willow grouse can vary between 2 to 20 pairs per km^2 (Marcström and Höglund 1980, Brittas 1988). Similar spring densities have been reported in Norway (Kastdalen 1992). The highest recording of spring numbers was made on Tranöy, averaging more than 70 pairs/km^2 during 1960-1980 (Myrberget 1989).

The annual variation in production of young is large, and several long term studies show that there can be between 0.5 and 6 young/pair in late summer/early fall (Marcström and Höglund 1980, Myrberget 1989). Considerable interest has been directed towards researching and determining the mechanisms behind these variations. A correlation with microtine cycles was recognised early on by Hagen (1952). Later studies have emphasised weather conditions (Höglund 1955, Slagsvold 1975), female breeding conditions and plant phenology (Brittas 1984) and predation (Myrberget 1975, Marcström and Höglund 1980).

Annual survival estimates for willow grouse in Scandinavia are mostly based on mark/recapture estimates. On Tranöy the apparent annual adult and young survival was 50% and 27%, respectively (Myrberget 1989, Steen and Erikstad 1996). Other studies have assumed an overall survival of 40% (Myrberget 1975) or an adult survival of 50% and survival of young as 40% (Kastdalen 1992). In a large study using radio-tagged individuals, the estimate of annual survival (starting September 1), was close to 40% (Smith & Willebrand, in press). Using 2.8 young per pair as a long term production average, a balanced population should have an average annual survival of 42%.

Patterns of annual fluctuations and long-term trends in Sweden can be found in time series of line transects using pointing dogs in Lövhögen, Härjedalen (>30 years), Arjeplogsfjällen, Norrbotten (>15 years). Fourteen new areas were selected for line transects with pointing dogs in 1994, six areas in Jämtland and eight areas in Norrbotten. Detailed bag statistics are available from several local hunting

organisations, most noticeable is Kiruna Jakt och Fiske, Norrbotten. However, interpretation on long term trends has to be careful using bag statistics.
Contrary to willow grouse the information on population dynamics of rock ptarmigan is limited. Few studies have been made in Norway or Sweden. A Norwegian study close to Nordkapp, has estimated spring densities to be between 33 and 113 ptarmigans per km^2 in different years. On Iceland where only rock ptarmigan is present, better studies of the population dynamics of this species have been conducted(Gardarsson 1988), showing a regular 10-year fluctuation pattern.

3. DISTANCE SAMPLING AND THE PRESENCE/ABSENCE INDEX AS DENSITY ESTIMATES

Point transect sampling belongs to a class of methods (distance sampling) that makes it possible to estimate the density **D** (number per unit area) of biological populations. The critical data collected are distances from a randomly placed line or point to objects of interest. A large proportion of the objects may go undetected, but the theory allows accurate estimates of density to be made under mild assumptions. Underlying the theory is the concept of a detection function **g(y)**, the probability of detecting an object given its distance (**y**) from the random line or point. The probability of detecting an object is assumed to decrease as the distance from the observer increases(Buckland *et al.* 1993).

The true detection function g(y) is not known, and it is advantageous if strong assumptions about the shape of the detection function can be avoided. A few models for g(y) that have desirable properties have been suggested by Buckland *et al.* (1993). The estimator of density is closely linked to g(y), and it is of critical importance to model for the detection function carefully. Estimates of density or abundance and their precision are made after the detection function has been modeled. A few computer programs have been developed to model the detection function and estimate density (see Buckland et al. 1992 for a description of the software DISTANCE). Akaikes Information Criterion (AIC) provides a quantitative method for model selection. AIC is computed for each candidate model and the model with the lowest AIC is selected (Buckland *et al.* 1993).

Cue rates are sometimes recorded instead of individuals, e.g. when calls can be heard without any visual contact. The method yields estimates of cue density which can be converted into grouse density by estimating a curate (p) from a separate study (Buckland *et al.* 1993).

In areas of thick cover or uneven terrain, the observer may rely heavily on sound detection alone, with only some of the detected birds being visible. Sometimes, birds are simply recorded according to whether they are within or beyond a specified distance c1 ($0<c1<\infty$). Only single-parameter models may suite such data, and it is not possible to test just how suitable such proposed models may be. If necessary, the distance may be accurately located with permanent markers, which helps even when detection is mostly aural. Hence, measuring difficulties are considerably reduced, and a single observer can gather a substantial data set in a season relative to complete census (Buckland *et al.* 1993).

Presence/absence is a frequency sampling method, and only worth noting if a species is present in an area or not. No distances are recorded, although the radius of the area searched has to be determined beforehand. This method allows the observers to census many points in a season, and the percent of the sampled points at which a species was recorded is an index of its abundance. The times series of this estimate can be used as a monitoring technique (Meir and Kareiva In press), and the frequencies in different habitats may be used as an index of habitat preference. There is always a risk of a false absence recording which can lead to bias or low precision of the estimate. However, the risk can be estimated by comparing two counts. When the area of interest is surveyed twice, the areas can be divided into four categories: (1.)Areas where the species was detected on the first survey but not on the second. (2.) Areas where the species was detected on the second survey but not on the first. (3.) Areas where the species was detected on both surveys, and (4.) areas where the species were missed on both surveys. The probability of a species being detected in an area on the first and the second survey can be calculated, and gives an estimate of the total number of areas where the species is present (Caughley 1974).

4. STUDY AREA

The study was conducted at the Ribovardo mountain (about 20 km^2, 520-875 m a.s.l.) in Vindelfjällens nature reserve, Västerbotten County, Sweden during March-May in 1997. The nature reserve is one of the largest conservation areas in Europe, with an area of 5 500 km^2. The altitude varies greatly from the lower valleys, which have an elevation of 500 to 600 m a.s.l, to the alpine peaks that reach a height of 1,500 to 1,700 m a.s.l.

The 30 sampling points were placed on a 1x1 km grid over the study area using the National Geographic grid. We believe that it is unlikely that this procedure introduced any systematic bias. The position of each point was found using a GPS-(Global Position System) reciever (GARMIN 45 XL). The points were censused in random order. Points were classified according to 4 major habitat features; high alpine areas with no vegetation over the snow (6 points), alpine areas with scattered mountain birch and brush (8 points), mountain birch forest with mountain birch cover of more than 50% of the area (11 points), and coniferous forest with dense mountain birch forest interspersed with coniferous forest (5 points). Each stratum was represented by the number of points in proportion to the habitats distribution in the whole area.

5. MATERIAL AND METHODS

In total, 24 willow grouse (14 females & 10 males) and 2 rock ptarmigans (1 female & 1 male) were captured during April before the census. We used cage-traps with branch-fences made of birch to lead the birds into the cages.The traps were checked each morning and evening. We classified individuals as juveniles (<1 year) or adults based on the quality and pigmentation of primaries, following Bergerud et al. (1963).

Weight, wing-length and secondary sexual characteristics to determine sex of adults were recorded. All grouse were fitted with a necklace radio-transmitter (10-12 g ; <4 % of juvenile body mass) and tagged with a patagial wing-tag.

To maximise the numbers of answers, the points were visited between 02.00 - 08.00 when willow grouse and rock ptarmigan males are most active (Steen 1989). Two observers were able to census 8 points each day. Each point was censused twice. We used snow-mobiles for transportation to and between the points. A portable tape-recorder with taped refrains of territorial males of willow grouse and rock ptarmigan was used in the census. Detection of grouse was recorded at each point during a minimum of 34 minutes.

When a point was reached, we waited 5 minutes before recording distances to calling grouse. The recording of grouse started with 15 minutes of passive listening, then taped refrains of 7 minutes willow grouse, followed by 7 minutes of rock ptarmigan. The taped refrains of the calls were 20 seconds long, separated by 10 seconds of silence. We did not census on days with strong wind and rain/snow. A laser range Finder (Bushnell Yardage pro 400) was used to estimate distances to observed grouse. The laser range finder did not give reliable estimates at long distances (>80 m) in appreciable precipitation or fog. Thus, each distance measurement was given a quality code depending on how exact the distance was estimated to be (bird observed, laser ranger used etc.). All observed males or calls (but not necessarily observed) were recorded as a response. The observer decided subjectively whether repeated calls came from a single or several individuals since cue counting was too variable to use as an index. (See Results.)

To evaluate how effective the taped refrains were in eliciting responses from territorial willow grouse males, we randomly picked 4 radio-tagged males and used the play-back technique at three distances, 50, 100 and 200 m. We determined the exact position of the grouse by taking many bearings at a distance between 50-100 m, and flushed each bird after the census. No taped calls of rock ptarmigan were played, and the period of passive listening was shortened to 7 minutes instead of 15. Only one distance was tested in a single day for each bird, with 2-3 days until the next test.

Density estimates were obtained from the sampled distances at each point by using the software DISTANCE (Buckland *et al.* 1993). The same software was used to estimate density by the binomial method, but we also used Microsoft Excel to construct a sheet for analysing density from distances in just 2 groups. We estimated the proportion of points that were wrongly determined as being absent of willow grouse following Caughley and Sinclair (1994). Microsoft Excel and SAS where used for all the other statistical analyses. During the analysis we truncated the data set by removing distances beyond 290 m, which were less than 16% of the data and provided little information. The quality code of these estimates was also lower than distances at close range.

6. RESULTS

6.1. Detection of grouse

Willow grouse were detected on 21 of the 30 points, whereas rock ptarmigans were only found on 6 points. Only one grouse was heard on any of the two occasions the 5 points were censused in the stratum containing coniferous forest. This stratum was excluded in most of the density estimations. Table 1 shows calls per point in each strata weighted by number of points, both counts pooled. Since only 26 calls from 7 individuals of rock ptarmigans were recorded it was difficult to analyse the response variation or abundance of this species.

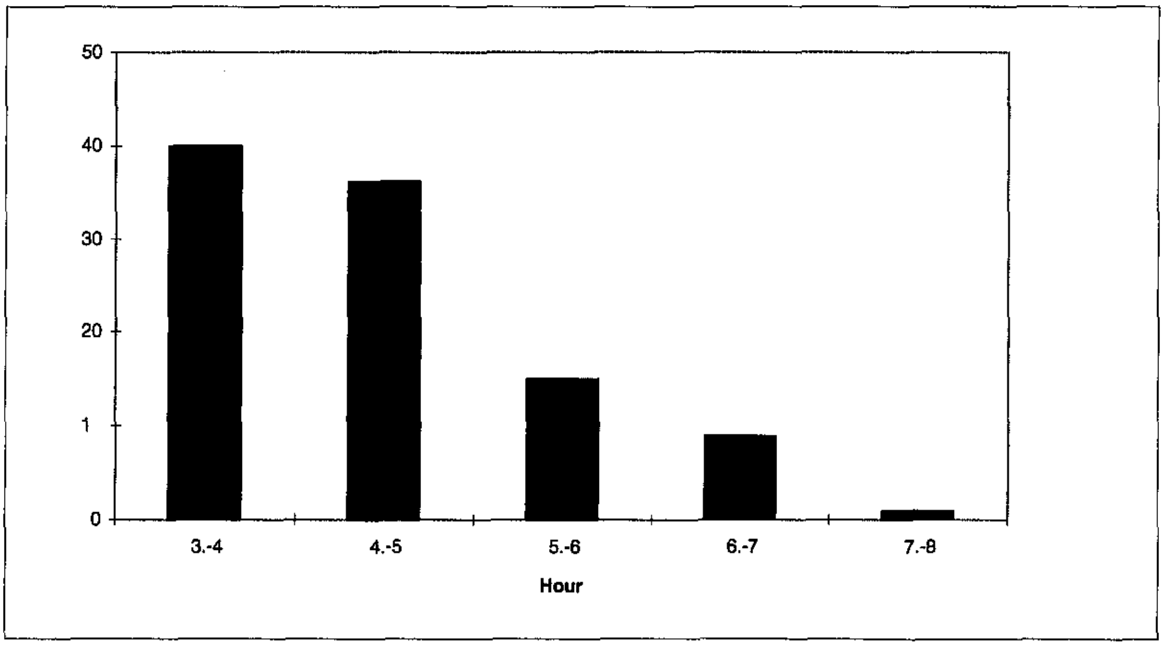
Table 1. Number of calls/point in each strata weighed by number of points.

STRATA	NO OF POINTS	WILLOW GROUSE	ROCK PTARMIGAN
1	5	4.2	2.0
2	8	5.5	1.4
3	11	5.3	0.3
4	6	0.2	0.0

Strata 1 = high alpine area; Strata 2 = alpine area; Strata 3 = mountain birch area; Strata 4 = coniferous forest area.

The calling rate of willow grouse and rock ptarmigan dropped half way through the study for both passive listening and the use of play-back calls. For willow grouse 81% of the calls were recorded before May 15 (for rock ptarmigan 85%), when half of the 60 counts had been made. The change in calling rate could not be explained by a change in distribution of males since all the radio-collared males remained within the study area throughout the test. The call rate was significantly higher when playback recordings of territorial males were used than when only listening passively (Pairwise t-test; t=2.821, d.f.=26, P<0.01, mean difference=0.075 calls/min.). However, the difference is minor and would be 0.75 more calls during a 10 minute session with play-back.. Rock ptarmigan males responded more strongly than willow grouse males to the playback calls (Pairwise t-test; t= 2.235, 6 d.f., P<0.05, mean difference=0.25 calls/min.), and could fly considerable distances (>400 m) to approach the point. The number of calls showed a decline after 05:00 (Fig.1) before May 15. After this date we started the counts one hour earlier, and most calls were obtained during 02:00-03:00. However, the general activity was low and the sample size is low (n=23).

Figure 1. Distribution of willow grouse calls recorded between 03:00 and 08:00 (percent within time period of total). Only data before May 15 are included (see text).



There was a large individual variation between the 4 randomly selected radio-collared males, with no or few calls recorded at the distance of 50 and 200 m (Table 2). One of the males did not call spontaneously or respond when provoked by the play-back calls at any distance. During the point transect, 6 willow grouse were recorded calling at a distance less than 50 m. There was no obvious difference in the weather (temperature/ precipitation/ clouds/ wind) that could explain the observed differences. Thus, there appeared to be a large individual difference in calling rate, although some of the variation may be explained by the drop in calling rate after May 15. Therefore, the estimated average conversion factor of calling rate into number of individuals was associated with a very large variance (C.V.>200%).

Table 2. Number of calls of radio collared willow grouse males during 7 min. passive listening and 7 min. play-back calls.

Distance (m)	Passive	Playback	Combined
50	0	0	0
100	0-8	0-8	0-16
200	0-2	0-2	0-4

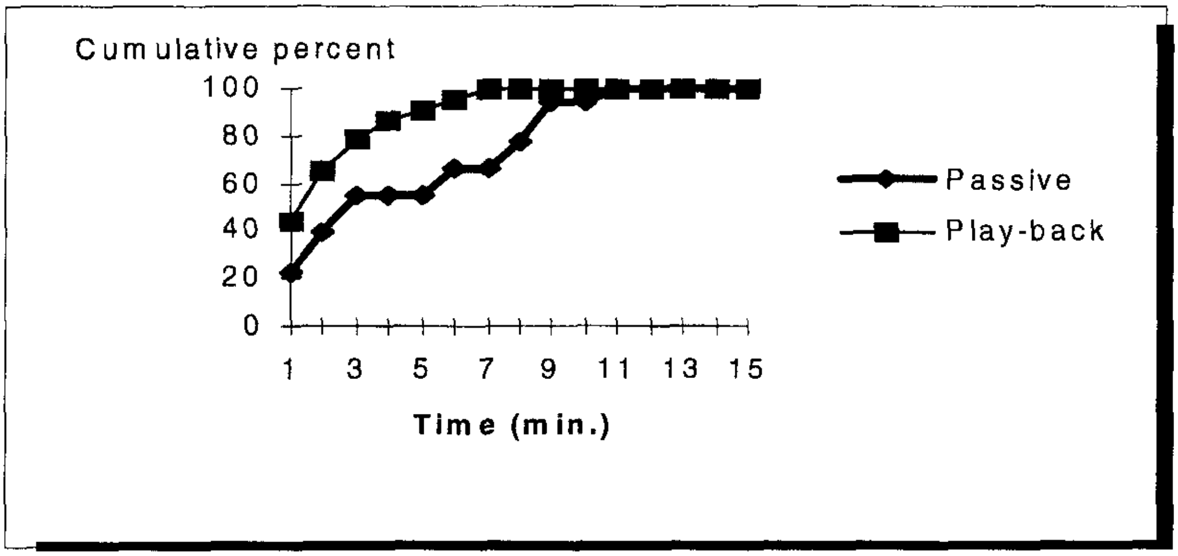
More calls were recorded closer to the observer when play-back calls were used than during passive listening (Table 3), ($chi^2 = 8.28$, $P < 0.02$, d.f.=2). Willow grouse also appeared to respond to play-backs of rock ptarmigan calls, although all play-backs of rock ptarmigan occurred immediately after playing willow grouse calls.

Table 3. *The distribution of recorded calls of willow grouse and rock ptarmigan males at different distances during passive listening and when using a tape recorder.*

Method	<150	150-300	>300
Passive	14	41	5
Play-back	41	41	8

The birds were detected faster when using the tape recorder compared to passive listening. When using the tape recorder 90 % of the points with grouse present were detected within 6 min. compared with passive listening when 90 % of the points with grouse present were detected after 10 min (Fig.2).

Figure 2. The cumulative distribution of time until the first call is registered during passive listening and play-back calls.



6.2. Estimation of abundance

We followed the recommendation by Buckland *et al.* (1993) when choosing an appropriate model for the detection function. Although the aim is to measure the distances exactly, it is often difficult to avoid heaping by rounding off, especially at larger distances. Eleven of 71 observations were excluded after initially selecting a truncation point at 290 m. These eleven recordings provided little value to the estimation of the detection function, and were of poorer quality than the points closer to the observer. Due to obvious heaping in the data set, we used intervals to avoid spikes in the distribution of distances.

The estimated effective detection radius (EDR) and density (D) from the distance analysis is presented in Table 4. Density estimates varied depending on which method was used. It was possible to stratify the distances by vegetation code and mode of listening (passive or play-back). We chose to compare the results from analysis with (A) strata 1-4, no stratification and all modes pooled, (B) play-back technique (willow grouse- and rock ptarmigan calls), strata 1-3 and density by stratum, (C) passive listening, strata 1-3 and density by strata, and (D) play-back technique (willow grouse calls), strata 1-3 and density by strata. The key functions selected were uniform plus one cosine term for method A and C, and half-normal plus one cosine term for method B and D. We did not analyse the recorded distances from rock ptarmigan due to a small sample size. The highest density and lowest CV was obtained in the analysis when passive listening was combined with play-back with willow grouse and rock ptarmigan play-back pooled. However, a large part of the variation in the density estimate is caused by the variation between points (60-80%). When the different techniques were treated separately, estimated density was highest for censuses made with tape-recorded willow grouse- and rock ptarmigan calls pooled.

Table 4. Effective detection radius (EDR) and density estimates (D) of willow grouse. Densities are presented for each stratum, and pooled.

Method*	Pts	N	EDR	D (1)	CV (%)	D (2)	CV (%)	D (3)	CV (%)	D (1-3)	CV (%)
A	30	45	159	-	-	-	-	-	-	9.4	27
B	24	24	126	14.6	43	6,3	64	6.0	71	10.1	37
C	24	21	168	6.7	42	3.5	54	3.4	43	5.0	31
D	24	21	128	12.3	44	4.8	59	5.8	71	8.5	37

*Methods: A = all modes pooled; B = play-back technique (W. grouse and R. ptarmigan calls); C = passive listening; D = play-back technique (W. grouse calls). Strata 1= high alpine area; Strata 2 = alpine area; Strata 3 =
mountain birch area; Strata 4 = coniferous forest area.

We used our data from the census to estimate willow grouse density with the binomial model (Table 5). The data was categorised into two groups by choosing a distance so that 80 % of the observations were within that distance recommended by Buckland et al. (1993), which analysed the half-normal model and concluded that this proportion of distances is the first category to optimal. The distances obtained in our study were 200 meters for all methods. Density results were compared from analysis with (A) all modes pooled, (B) play-back technique (willow grouse- and rock ptarmigan calls), (C) passive listening, and (D) play-back technique (willow grouse calls).

Table 5. Density estimates obtained by the binomial method.

Method*	N	Density	CV(%)
A	42	10.5	28
B	23	7.2	33
C	19	6.2	36
D	20	6.0	34

*Methods: A = all modes pooled; B = play-back technique (W. grouse and R. ptarmigan calls);
C = passive listening; D = play-back technique (W. grouse calls).

The estimated true number of points with grouse (Caughley and Sinclair 1992) is shown in Table 6. We compared the results from analysis with passive listening, and play-back listening at four distances for willow grouse. The highest density estimate was from the data set calculated for the play-back technique at distance 500 meters.

Table 6. Density estimates (Y) and number of points with willow grouse observed both-, first-, and second survey obtained by the present/absent method. Densities are presented for four distances.

Distance	PASSIVE				PLAY-BACK			
(m)	N(both)	N(first)	N(sec.)	Y(s.e.)	N(both)	N(first)	N(sec.)	Y (s.e.)
500	5	6	1	13.0 (1.4)	3	12	2	23.0 (5.3)
300	4	7	1	13.4 (1.8)	3	11	2	21.5 (5.0)
200	2	9	1	15.0 (3.5)	2	10	1	16.3 (3.8)

To find the optimal radius, the number of points that were wrongly recorded as lacking willow grouse (absent) was estimated. The number of false absence points increased from the first to the second count (Table 7).

Table 7. The estimated percentage of points where a true presence was wrongly determined as absence at different radii.

Radius	Passive		Play-back	
(meter)	First	Second	First	Second
500	17	55	40	80
300	20	64	39	80
200	40	77	33	82

7. DISCUSSION

The approach of using exact distances in density estimation provided only a small advantage over the binomial model with only 2 intervals. The average density and CV-values were similar for both methods, even when we removed the points in the mixed coniferous forest and stratified the remaining points according to habitat in the analysis. These findings are somewhat contrary to earlier investigations which have shown that the effectiveness of the binomial model for estimating density relative to the half-normal model applied to ungrouped distances, is about 65-80% (Ramsey and Scott 1979, Buckland *et al.* 1987). The poor precision obtained when determining the distances to calling males and the large variation between points are probably the most important explanations to our results. We had to categorize the distances in 5 intervals due to spikes and uncertainty in the data set.

We believe it to be difficult to increase the precision in measuring distances in settings such as in this study. The range finder was a valuable tool to measure exact distances in clear weather and open landscape when the location of the grouse was known. But the range finder worked poorly in bad weather, or could not be used when vegetation obscured the sight of the calling grouse. Furthermore, it is not possible for an observer to leave the point to improve the precision of the distance measurement since that would introduce the risk of disturbing the grouse. Thus, we believe that it is impossible to record exact distances with such accuracy that the advantages of this approach are attained. It is possible to reach a high enough precision in areas with higher densities and/or more intense calling rates. We conclude that the binomial model is to be preferred in areas similar to our study area where an estimate of true density (grouse/area) is desired.

It is sometimes possible to convert a detection of cues (calls) into a cue rate. It is then possible to estimate the density of cues and convert it to density of individuals. We found the individual variation in calling rate too large, making it difficult to use the cue rate as our observation unit. We found it more practical to subjectively estimate whether several calls originated from one or more individuals from time to time. It will of course be important that this procedure be calibrated between observers participating in a monitoring program. Some individuals showed a low calling activity, and there was a tendency for males close to the point not to call. This could seriously bias the results, since the detection would then increase rather than decrease with increasing distance in some interval.

The distance that would divide the data in two intervals for the binomial model was estimated at 200 metres by including 80% of the observations in the first interval. This procedure was possible since we had recorded exact distances during the count. It would have been hard to select the range of the 2 intervals beforehand. We sometimes found it difficult to determine if a calling grouse was within or beyond this distance but it will hardly be worthwhile putting out permanent markers in this situation, as done in other studies (Bibby *et al.* 1992). Instead, we emphasize the importance of training all personnel in determining distances under realistic field conditions, using a range finder. A disadvantage with the binomial model is that it is not possible to test whether or not the estimated detection function is reasonable (Buckland *et al.* 1992). However, any bias from fitting the model is most likely similar between years.

Fewer grouse were detected at shorter distances using passive listening than when the tape recorder was used. We suggest this was caused by males moving towards the play-back calls, since it resulted in a shift of the distribution of distances rather than increased the number of males/calls. This would introduce bias in the results since the effective detection radius would be too short and the area covered underestimated. Thus, we cannot recommend the use of play-back technique when sampling distances. Other studies (i.e. Johnson *et al.* 1981) have found several advantages with the play-back technique, e.g. increased numbers of individuals detected, time efficient sampling, and detection of problematic species.

The study of distribution of species often uses information on whether a species is present or absent from sampled areas (Bibby *et al.* 1992). It has also been suggested as an index of population change in monitoring programs (Meir and Kareiva, in press). The probability of an individual being within an area depends on density, aggregation and the size of the sampled plots. An advantage with the presence/absence approach is that it will not suffer from low sample size (few detections) as those based on distance sampling. More points were detected with grouse present when play-back calls were used, especially if the radius was set at 100 m. The number of points with a detected presence of grouse increased with an increase in radius, and we suggest a radius of 300 m to be most practical for a presence/absence study of willow grouse at these densities. Then it would be possible to estimate if a bird is inside or outside the radius and loss of accuracy would be acceptable. Most of the recorded birds during our census were detected at distances shorter than that. The time spent at each point can be reduced, since the number of grouse or calls are not recorded. Our results show that more than 90% of the points with grouse present were detected within 10 min. and 6 min. respectively for passive listening and when using the play-back calls.

A problem with the presence/absence method is that some points will be falsely detected as absence of grouse. In one of our estimates for example, using a radius of 300 metres and passive listening, we estimated the number of false absence to 2 and 8 points (20% vs. 64%, first and second visit). It is therefore important that the count is performed under conditions when risk of false absence recordings are low. This is especially important when the available resources are not sufficient to perform a repeated count, and the true number of points with grouse present can be estimated. Using the play-back calls will reduce the time needed to wait at each point by 50%, and with our suggested radius of 300 metres, the risk of attracting males outside the area seems minimal.

The drop in calling activity halfway through the study had a large affect on the number of recordings at the second count, and only using the first count increased the estimated density by 20%. The change in calling rate could not be explained by a reduction in number of males in the area since all of the radio-collared males remained within the study site throughout the test. It has earlier been shown that willow grouse males remain close to their territories all year around (Smith and Willebrand, pers. comm.) . It is well known that the calling activity of willow grouse shows two peaks - with a period of about a week each in spring (Pedersen *et al.* 1992). The first occurs when the territories are established in late April/early May, and the second takes place when females select a male for mating in late May. Although these events are highly synchronized within a year they can vary up to two weeks between years depending on weather and snow cover. We conclude that it will be important to correctly determine the peak each year and not plan a count that is more than a week long.

Stratification allows separate estimates of the means and variances to be made for each stratum and allows the overall mean and variances to be estimated with greater precision. Our stratification resulted in a clear boundary in the presence of grouse between the conifer mixed forest and the strata on higher ground. We believe this result to apply to habitats where the conifer part is dominated by Norway spruce, as in this part of the mountain range. In other parts of the range, willow grouse can be found where this lower strata is dominated by bogs and Scots Pine (Willebrand, pers. com., Steen 1989). The stratified analysis showed a tendency for higher densities in the strata dominated by mountain birch but the variation is large due to a low sample size. We suggest that a monitoring program should concentrate its effort on only 2 strata. It is more effective only to census in one central and uniform habitat with expected high densities and one edge habitat with lower densities more prone to be influenced by factor of change. The population in the edge habitat may occupy a habitat type characterized by a reproductive output too small to maintain local population levels. The densities will decline earlier in these edge areas and influence the population dynamics in the core areas and promote a higher emigration rate (Pulliam 1988).

We obtained too few distances to calling males of rock ptarmigan to make it possible to compare different techniques. It was obvious that using a tape recorder attracted rock ptarmigan males from far distances making the play-back technique unsuitable for all techniques, even presence/absence. Thus, play-back calls should not be used in counts where both species are counted which would probably be the case in a monitoring program. Within one site, the core area for willow grouse would then be edge habitat for rock ptarmigan and vice versa. However, depending on the aims it might be desirable to get a more complete cover of willow grouse and then it might be necessary to place a counting site in the mixed bog/conifer forest area.

We suggest that either the binomial method or the presence/absence index to be the two alternatives for monitoring spring populations of willow grouse and rock ptarmigan. The choice depends on the aim. The binomial method should be used if the aim includes estimation of the prey base for gyrfalcon or evaluation of gag size since it will provide an estimate of true density. The presence/absence method is probably more suitable if the aim is to detect any long term trend. Presence/absence makes it possible to count more points, and will make it possible to add more sites to the monitoring program. We estimate that two observers on snowmobiles can count 75 (binomial) and 150 (presence/absence) points in a weeks time. If about 30 points is counted once (no repeat) at each site it is possible to monitor 2-3 sites with the binomial and 5 sites with the presence/absence method. Trained observers and carefully identifying the peak of calling activity is crucial for both methods. It will only be possible to count during the first peak, since the snow conditions during the second will make it difficult and time consuming to move between sites and points.

We suggest that the performance of alternative monitoring programs are modeled by creating simulated populations on which the different programs can be tested. It will give an indication on the probability of achieving desired goals as well as identifying weak parts in assumptions and logistic design. Once a larger monitoring program has been launched it will almost be impossible to change methods due to loss of earlier investments in collected data.

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SUMMARY

Almoust all decisions on how a population might be managed require either information on density, on trend in density, or on both. At all professional levels, there is a need for accurate and reliable monitoring programs for management and conservation of wildlife populations.

Willow grouse and rock ptarmigan are being considered as suitable monitoring species of the mountain range if robust methods with enough precision can be developed. To evaluate possible methods to monitor spring densities of willow grouse and rock ptarmigan, this study was conducted at the Ribovardo mountain in Vindelfjällens nature reserve, Västerbottens County, Sweden in spring 1997. The data collected was used to estimate density by distance sampling using exact distances, distance sampling using only one distance (binomial method), and only determining if the species of interest was present or absent within a given radius of a point. We compared the rate of detection when using taped refrains of territorial males with only passive listening. Males fitted with radio-transmitters were used to evaluate response-rates.

The most efficient use of resources to obtain an estimate of willow grouse spring populations is the binomial method if an estimate of true density is required, and the presence/absence index if the aim is to detect any long time trend. Sample sizes of rock ptarmigan were too small, making it impossible to compare different techniques for that species.

We suggest that the performance of alternative monitoring programs are modelled by creating simulated populations on which the different programs can be tested. It will give an indication on the probability of achieving desired goals as well as identifying weak parts in assumptions and logistic design.

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